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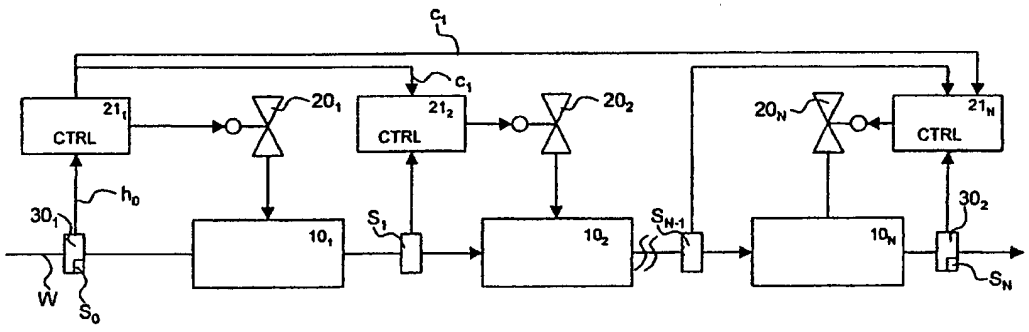
(54) Title: METHOD AND APPARATUS FOR CONTROL OF DRYING PROCESS TAKING PLACE IN A PULP DRYER



(57) Abstract: The invention concerns a method for control of the drying process taking place in a pulp dryer, which pulp dryer comprises several blowing fan levels, from which drying gas is blown on both sides of the web, and which method comprises measuring the web's moisture information (h_o) on the web section entering the pulp dryer by a first moisture sensor (S_o) and measuring the web's moisture information (h_N) on the emerging web section by a later moisture sensor (S_N). In addition, the method comprises dividing the pulp dryer (10) into two or more drying sections (10_1,...IO_N) and controlling the moisture level of the pulp web (W) separately in each drying section (10_1,... IO_N). The invention also concerns an apparatus for control of the drying process taking place in a pulp dryer, in which apparatus the pulp dryer comprises several blowing fan levels, from which blowing of drying gas is arranged on both sides of the web and wherein a first moisture sensor (S_1) is arranged for the web section entering the pulp dryer and a last moisture sensor (S_N) is arranged for the web section emerging from the pulp dryer, and wherein the pulp web's moisture level existing in the pulp dryer is controlled by a steam valve/steam valves. In the apparatus according to the invention the pulp dryer (10) is divided into two or more drying sections (10_1,...IO_N) and a separate control of the moisture level of the pulp web (W) is arranged for each drying section (10_1,...IO_N).

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Method and apparatus for control of drying process taking place in a pulp dryer

The invention concerns a method and apparatus for control of the drying process taking place in a pulp dryer.

Pulp dryers according to the state of the art operate in the following manner. The wet pulp web arriving from the press with a dry matter content of approximately 50 % at this stage is usually fed from above into the pulp dryer, which includes several blowing fan levels. The blowing fan levels are formed by fan boxes mounted adjacent to each other over the whole cross-sectional area of the web and over the pulp dryer length. From the fan levels a drying gas is blown, which is e.g. hot air, steam or any other medium suitable for the purpose, through a nozzle from both sides towards the web. In such a contact-free drying the web travels back and forth inside the pulp dryer moving from an upper level towards the lower part of the pulp dryer. As the web is leaving the lower part of the pulp dryer, the dry matter content of the web is typically about 90 %.

Depending on the dryer size there is a section of the web with an approximate length of one kilometre inside the pulp dryer at all times, and the velocity of this web section is between 150 and 250 m/min. Hereby the transit time through the pulp dryer is in a range of 4 – 6 min. During this time the dry matter content of the web increases constantly as the web proceeds in the dryer. According to the state of the art, the drying is typically controlled by one steam valve affecting all blowing fan levels of the entire pulp dryer. The steam valve is regulated according to the moisture information measured in the web after the pulp dryer. Hereby it is very difficult to perform a quick and exact control of the web's final moisture in the different moisture variation situations. A pulp dryer is known, for example, from the **FI** Patent Publication **102 981**.

The problems in the moisture control taking place in the pulp dryer expose the pulp web to web breaks. Problems are also caused when machine speeds are increased and when the basis weight of the pulp web is increased. In addition, in connection with grade changes the characteristics of the pulp web will change, for example, as the basis weight and the fibre grades of the pulp are changed. Controlling the web moisture becomes more difficult also in these situations. Web breaks usually occur more frequently in the top part of the pulp dryer, where the web is wettest.

The **WO** publication **99/198405** presents a method for controlling the process variables of drying gases in a dryer. This method measures and controls the process variables of water vapour evaporating from the web as well as the pressure inside the dryer. These variables are controlled independently of each other. In addition, the method controls the process variables of the steam supplied into the dryer and of the steam leaving the dryer, and both groups of process variables are used to control the drying process. The publication does not mention any utilisation of moisture measurement in the control of drying.

The purpose of the present invention is to bring about a quicker and more exact method than the present ones for controlling and managing the moisture profile of a pulp web in the machine direction.

It is also a purpose of the present invention to bring about a better moisture control for the pulp web in connection with a change of grades.

The method according to the invention is mainly characterised by dividing the pulp dryer into two or more drying sections and controlling the moisture level of the pulp web separately in each drying section.

The apparatus according to the invention is characterised in that the pulp dryer is divided into two or more drying sections and a separate moisture level control of the pulp web is arranged for each drying section.

According to the invention, the pulp dryer is divided into two or more sections, each one of which is controlled by its own steam valve. In the method according to the invention, the moisture control of the pulp dryer is improved in such a way that the moisture measurement to be performed in the web section between the press and the pulp dryer and/or between the drying sections is utilised to regulate the steam valves of the pulp dryer. According to the invention, the information obtained from the measurement points is taken to the control unit of the steam valve controlling the section corresponding to the measurement point of the pulp dryer, which control unit in addition to this preferably uses as control information also the basis weight measurement information and the machine speed information. In this manner the moisture information of the web arriving in the drying section can be used by controlling the steam valve in a derivative manner. The final moisture of the web after the dryer can also be taken into account at the same time.

Hereby the sections of the dryer divided into two or more parts can be controlled more exactly than before by their own steam valves.

With the method according to the invention several advantages are achieved compared with state-of-the-art moisture control. Moisture variations after the press can be quickly eliminated by the method according to the invention. In addition, the better moisture management will reduce the occurrence of web breaks. The method according to the invention can be implemented by converting existing control systems, whereby implementation of the invention will not require any significant investment costs.

By using the method according to the invention the total evaporation of the pulp dryer can be calculated more easily and more exactly and this information can be used in the energy management of the pulp dryer and in trouble diagnostics. At the same time, moisture control during grade change is facilitated thanks to the improved control.

In the following, the invention will be described in greater detail with reference to the appended figures, wherein:

Figure 1 shows a state-of-the-art control system for a pulp dryer.

Figure 2 shows the moisture profile of the pulp dryer in the machine direction.

Figure 3 shows a block diagram of the control method according to the invention.

Figure 4 shows another embodiment of the invention, wherein the pulp dryer is divided into several sections.

Figure 5 shows an embodiment of the invention, which also includes control of the blowing speed of airborne web dryers.

Figure 1 shows a state-of-the-art control system for a pulp dryer. A Web W arrives from a press P and it is taken through the top part of the pulp dryer 10 into the pulp dryer 10. The pulp dryer 10 includes turning rolls 11 supporting the web W and blowing fan levels for drying the web W. In the pulp dryer 10 the web W travels supported by the turning rolls 11 between the different blowing fan levels. The blowing fan levels include hot air blowing boxes 12, from which hot air is blown through nozzles towards the web from both sides. The web W travels in the dryer 10 through the blowing fan levels step by step from the top downwards and it leaves the dryer 10 through the lower part.

In the web section between the pulp dryer 10 and the press P, the moisture of the pulp web W is observed by a first moisture sensor S_0, which is mounted to a measuring beam 30_1 or which is separate. The first moisture sensor S_0 may be either a spot measurement sensor or a sensor moving over the cross machine direction of the web back and forth across its width, or any other suitable means measuring the moisture. After the pulp dryer 10 the moisture of the web W is measured by a later moisture sensor S_N, which is located in connection with a measuring beam 30_2, and this moisture information h_N is used in the control unit 21 of a steam valve 20 to control the moisture degree of the pulp web W. The later moisture sensor S_N may also function as a sensor separate from the measuring beam 30_2. Measurement information on the basis weight BW and on the machine velocity v is preferably also brought to the control unit 21.

Figure 2 shows the moisture profile of the pulp web W in the machine direction inside the pulp dryer, when the moisture content of the pulp web changes in the desired manner. The vertical axis shows the moisture content of the pulp web on an arbitrary scale, while the horizontal axis shows the location of the pulp web inside the pulp dryer. According to the curve shown in the figure, the moisture content of the pulp web is highest at the inlet to the pulp dryer (0 m), and the moisture content drops evenly when travelling towards the final end of the pulp dryer (900 m). The allowed range of variation of the moisture content is also shown by dashed lines in Figure 2, within which range the moisture content may be controlled by the method according to the invention.

Figure 3 shows an embodiment of the present invention, wherein the pulp dryer 10' is divided into two sections 10'a, 10'b. From a first moisture sensor S_0 connected to the web section between the press P and the pulp dryer 10', which first moisture sensor is either separate or is mounted to a measuring beam 30_1, moisture information h_0 is taken to the control unit 21'a of the steam valve 20'a of the first drying section 10'a. The first moisture sensor S_0 is either a spot measurement sensor or a sensor moving over the cross machine direction of the

web back and forth across its width or any other moisture measuring means suitable for the purpose. From a later moisture sensor S_N connected after pulp dryer 10' a moisture measurement signal h_N is taken to a web moisture management unit 22'b, which supplies a control signal to the control unit 21'b of the steam valve 20'b of the second section 10'b. The control unit 21'b of the steam valve 20'b of the second section 10'b receives from a steam pressure measurement unit 23 a steam pressure value p_b, which is preferably used in the continuous regulation of the control unit 21'b of the steam valve.

Information on the basis weight measurement BW and on the machine velocity v is preferably supplied both to the control unit 21'a of the steam valve in the first section and to the moisture management unit 22'b. Measuring of the basis weight BV can be performed either by a basis weight sensor mounted to measuring beam 30_1 or the basis weight information may be supplied in other ways to control unit 21'a.

The moisture level of the web W is regulated by supplying steam into the drying sections, which steam dries the web W. By moisture measurements of the web W the moisture level of the web W is observed and the quantity of the steam to be supplied is measured by steam pressure measurements in the steam to be supplied. The pressure and/or quantity of the steam is controlled by a steam valve. The setting value of the web's W moisture circle is changed e.g. separately for each grade, and according to the invention the control of the steam valve is changed continuously as a function of time. The feedforward of moisture information h_0 according to the invention from the first moisture sensor S_0 to the control unit 21'a of the steam valve 20'a of the first section 10'a results in a more exact and quicker moisture control for the pulp dryer 10.

Figure 4 shows an embodiment of the invention, wherein the pulp dryer 10 is divided into more than two drying sections 10_1, 10_2, ..., 10_N. Each drying section may be e.g. one blowing fan level of the pulp dryer 10 including the travelling

level of the web W and blowing fan boxes 12 placed on its both sides. Each drying section 10_1, ... 10_N is controlled in a similar manner by steam valves 20_1, ..., 20_N, which for their part are similarly controlled by control units 21_1, ..., 21_N. A first moisture sensor S_0 is located before the pulp dryer 10. In the section between drying section 10_1 and drying section 10_2, for example, in connection with the turning roll, a second moisture sensor S_1 is located. Correspondingly, a moisture sensor S_{N-1} is located before the last drying section 10_N, and after the last drying section 10_N, that is, in the web section located at the outlet of the pulp dryer, a moisture sensor S_N is located, which measures the final moisture of the pulp web W after the pulp dryer 10.

The moisture information h_0 of moisture sensor S_0 is taken to control the unit 21_1, which controls the steam valve 20_1. In addition, information on the web's basis weight and velocity may be taken to the control unit 21_1, and this information may also be used to control the valve 20_1. In this manner feedforward is achieved from the moisture sensor S_0 before the pulp dryer to control the drying section 10_1. A control signal c_1 may also be taken from the control unit 21_1 to one or more control units 21_2, ..., 20_N of the steam valves 20_2, ..., 20_N located later. Hereby the control signal c_1 may be either moisture measurement information or valve control information. In this manner feedforward is achieved from the moisture sensor S_0 before the pulp dryer in order to control one or more drying sections 10_1, ..., 10_N of the pulp dryer 10. The control may take place either based only on the signal arriving from the control unit 21_1 or based only on the signal from the control unit prior to the concerned drying section (e.g. drying section 10_2 would be controlled based only on the control signal of the control unit 21_2) or by using both signals. Each section 10_1, ..., 10_N of the pulp dryer is controlled in a similar manner by a moisture sensor S_1, ..., S_{N-1} located before each section. In addition, the last section 10_N of the pulp dryer 10 is controlled in a feedback manner based on the measurement information from the moisture sensor S_N located after the pulp dryer. According to the invention, at least one drying section 10_1, ..., 10_N of the pulp dryer is controlled in a feedforward manner and at least one drying

section is controlled in a feedback manner. Feedback preferably takes place based on the measurement information of the last section.

Figure 5 shows an embodiment of the present invention wherein the moisture information is used for controlling the blowing speed of the pulp dryer's blowing boxes. In this embodiment the first section 10_1 of the pulp dryer is controlled in the same manner as was described earlier. From the later moisture sensor S_N located after the pulp dryer measurement information h_N is obtained, which is taken to the control unit 12_C for the blowing speed of the blowing boxes 12, which control unit controls the blowing speed of the blowing boxes 12. The moisture information h_N obtained from moisture sensor S_N is also taken to the control unit 21_N for the steam valve 20_N, which controls the pulp dryer's steam valve in the manner described above. The embodiment of the invention shown in Figure 5 may also be combined with the control options presented in Figure 4. In Figure 5 the blowing speed control of blowing boxes is shown in connection with one drying section only, but it is possible to implement the control also in more drying sections. Especially the drying sections in the final end of the drying part are preferably controlled.

It is very difficult to calculate the required target values for the steam pressure of steam valves 20'a; 20'b; 20_1, ..., 20_N when the grade is changed in pulp dryer 10. In consequence of this the steam valves cannot be ramped to control the final moisture content of the web when the grade is changed. It is an advantage of the method according to the invention that the method makes it possible to perform moisture control also during grade changes, whereby the final moisture content can be managed also in such process change situations. During a change of grade it is possible to speed up some adjustments of control settings when required. Different fibre grades act in different ways as regards water removal, whereby each fibre grade demands its own process model and the process amplification is changed according to this model after grade changes. The process models are

mathematical models known as such and based on physical principles and on response tests or other experimental methods.

In the method according to the invention described above the web moisture is measured before and after the pulp dryer in a manner known as such, wherein the moisture sensor measures the web moisture either as spot measurement or by a traversing measuring device over the entire web width or by some other moisture-measuring method suitable for the purpose. According to the invention, the measured moisture information is utilised in a new manner, wherein the web moisture information measured before the pulp dryer is taken in a feedforward manner to a steam valve performing continuous control of the quantity of steam supplied to the pulp dryer. Alternatively, feedback moisture control can also be used to control the blowing speed of blowing boxes 12. Alternatively, this control may be implemented by feedforwarding the measurement information of the first moisture sensor to the control unit of the blowing boxes.

In the following the claims are presented, but the intention is not to limit the invention to these only.

Claims

1. Method for control of the drying process taking place in a pulp dryer, which pulp dryer comprises several blowing fan levels, from which drying gas is blown on to both sides of the web, and which method comprising measuring the web's moisture information (h_0) on the web section entering the pulp dryer by a first moisture sensor (S_0), and measuring the web's moisture information (h_N) on the emerging web section by a later moisture sensor (S_N), **characterised** by dividing the pulp dryer (10) into two or more drying sections (10_1, ...,10_N) and controlling the moisture level of the pulp web (W) separately in each drying section (10_1, ..., 10_N).

2. Method according to claim 1, **characterised** by controlling the moisture level of the pulp web (W) continuously.

3. Method according to claim 1 or 2, **characterised** by controlling at least one drying section (10_1, ..., 10_N) of the pulp dryer in a feedforward manner and at least one drying section (10_1, ..., 10_N) in a feedback manner.

4. Method according to any one of claims 1 - 3, **characterised** by implementing feedback of the pulp dryer's (10) control on the basis of the measurement information of the last section (10_N).

5. Method according to any one of claims 1 - 4, **characterised** by controlling the pulp web's (W) moisture level with steam valves (20; 20'a; 20'b; 20_1,..., 20_N).

6. Method according to any one of claims 1 - 5, **characterised** by controlling the pulp web's (W) moisture level by regulating the quantity of steam supplied to the drying section (10_1, ..., 10_N).

7. Method according to any one of claims 1 - 6, **characterised** by controlling the steam valve (20; 20'a; 20'b; 20_1, ..., 20_N) of the pulp dryer's (10) drying section (10_1, ..., 10_N) on the basis of the measurement information of the moisture sensor (S_0,..., S_{N-1}) located before the drying section.

8. Method according to any one of claims 1 - 7, **characterised** by dividing the pulp dryer (10') into two drying sections (10'a, 10'b), of which the first section (10'a) being controlled by the first steam valve (20'a) and the second section (10'b) being controlled by the second steam valve (20'b).

9. Method according to any one of claims 1 - 8, **characterised** by controlling the steam valve (20'a) of the first section (10'a) by the first moisture sensor (S_0) located before the pulp dryer (10') and by controlling the steam valve (20'b) of the later section (10'b) by the later moisture sensor (S_N) located after the pulp dryer (10').

10. Method according to any one of claims 1 - 9, **characterised** by using the measurement information of the moisture sensor/moisture sensors (S_0,...,S_N) for controlling the blowing speed of blowing boxes (12).

11. Method according to any one of claims 1 - 10, **characterised** by bringing the information from measurement of the basis weight (BW) and of the machine velocity (v) to the control unit (21; 21'a; 21'b; 21_1, ..., 21_N) of the steam valve (20; 20'a; 20'b; 20_1, ..., 20_N).

12. Method according to any one of claims 1 - 11, **characterised** by controlling the operation of the press (P) on the basis of measurement information (h_0) given by the first moisture sensor (S_0) located before the pulp dryer (10).

13. Apparatus for control of the drying process taking place in a pulp dryer, in which apparatus the pulp dryer comprises several blowing fan levels, from

which the blowing of drying gas is arranged on both sides of the web and wherein a first moisture sensor (S_1) is arranged for the web section entering the pulp dryer and a last moisture sensor (S_N) is arranged for the web section emerging from the pulp dryer, and wherein the pulp web's moisture level existing in the pulp dryer is controlled by a steam valve/steam valves, **characterised** in that the pulp dryer (10) is divided into two or more drying sections ($10_1,\ldots,10_N$), in which a separate control of the pulp web's (W) moisture level is arranged for each drying section ($10_1,\ldots,10_N$).

14. Apparatus according to claim 13, **characterised** in that the moisture control of each drying section ($10_1,\ldots,10_N$) in the pulp dryer is continuous and it is arranged by a steam valve (20; 20'a; 20'b; 20_1, ..., 20_N), the control of which is arranged by a control unit (21; 21'a; 21'b; 21_1, ..., 21_N).

15. Apparatus according to claim 13 or 14, **characterised** in that the control for the steam valve (20_1) of the pulp dryer's (10) first drying section (10_1) is accomplished on the basis of the measurement information (h_0) given by the first moisture sensor (S_0).

16. Apparatus according to any one of claims 13 - 15, **characterised** in that a moisture sensor ($S_1,\ldots,S_{N-1}$) is arranged in between the pulp dryer's (10) drying sections ($10_1,\ldots,10_N$).

17. Apparatus according to any one of claims 13 - 16, **characterised** in that each moisture sensor ($S_0,\ldots,S_{N-1}$) in a similar manner controls the pulp dryer section ($10_1,\ldots,10_N$) located after the moisture sensor.

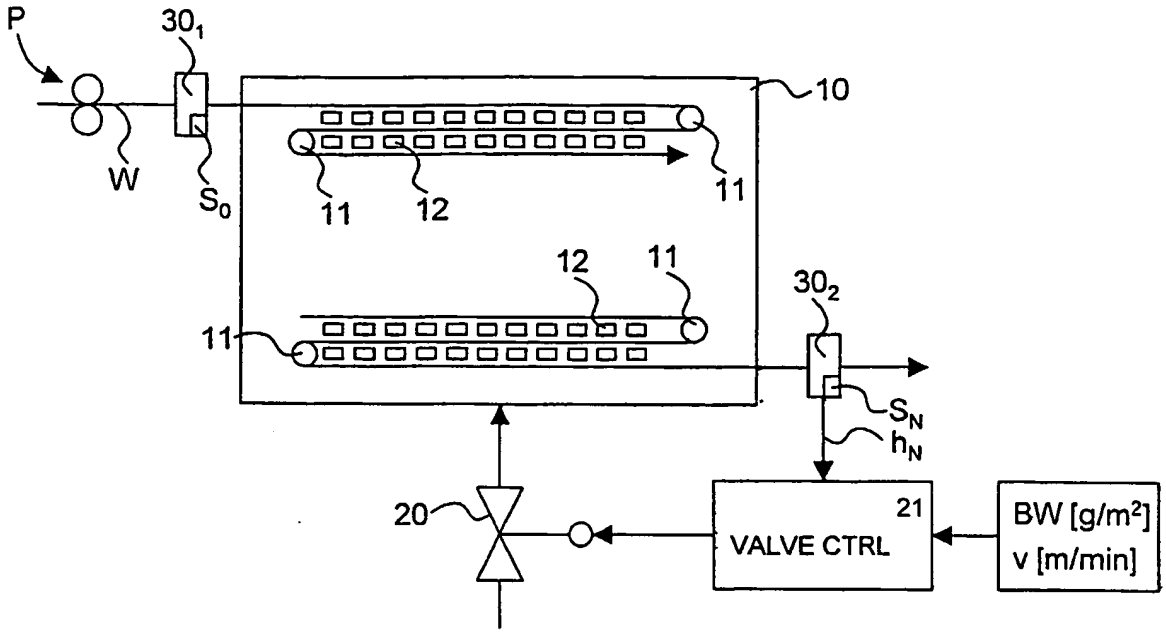

FIG. 1 Prior art

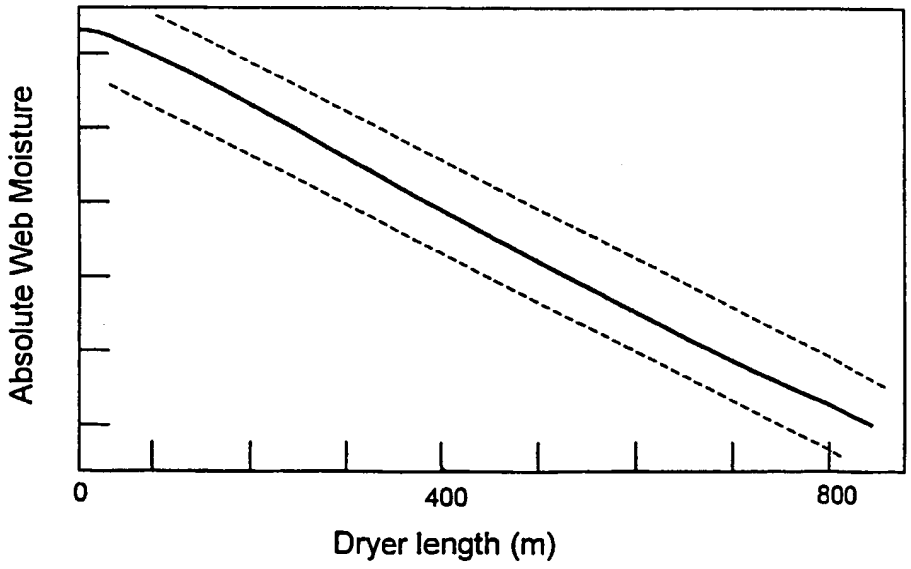

FIG. 2

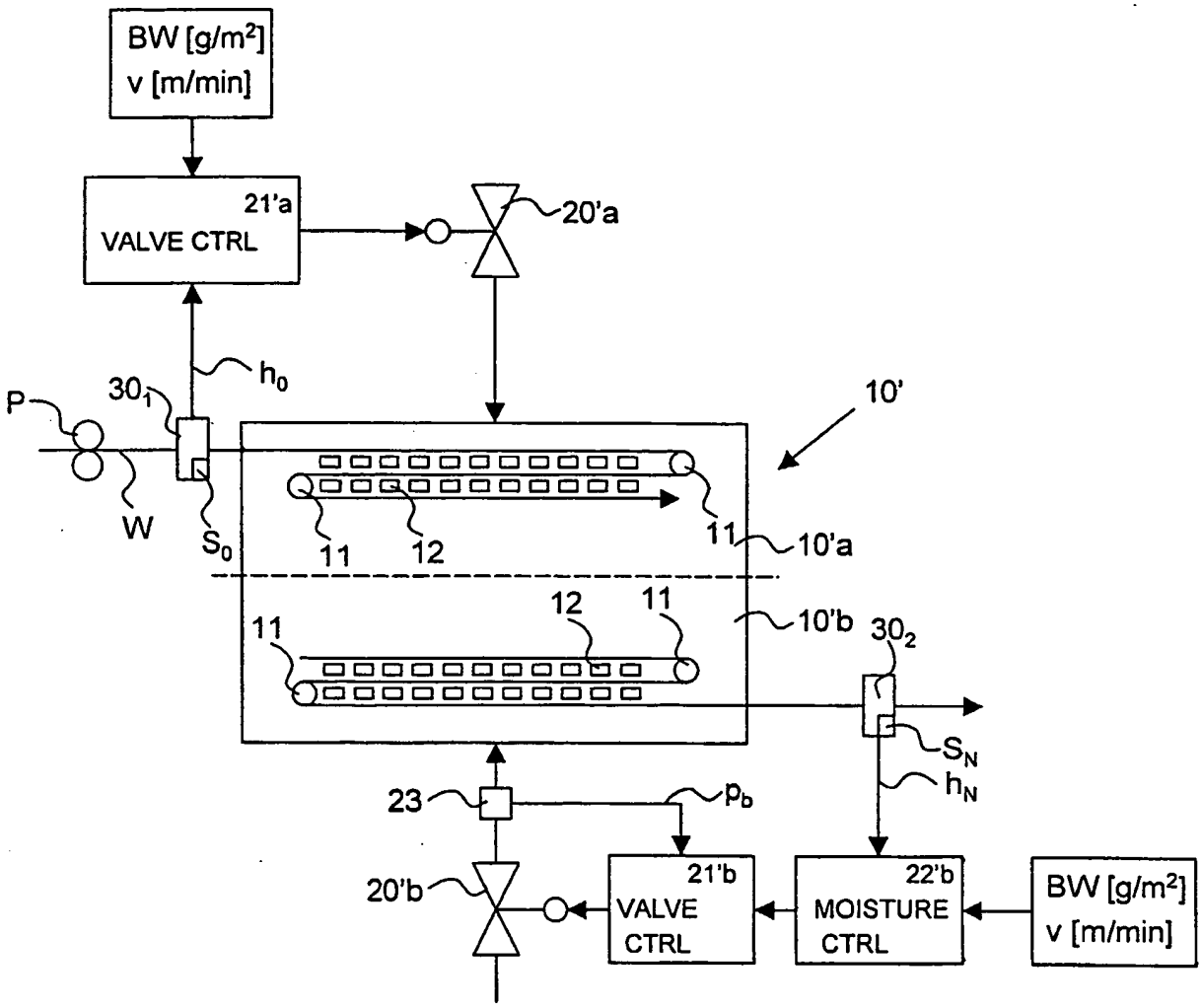
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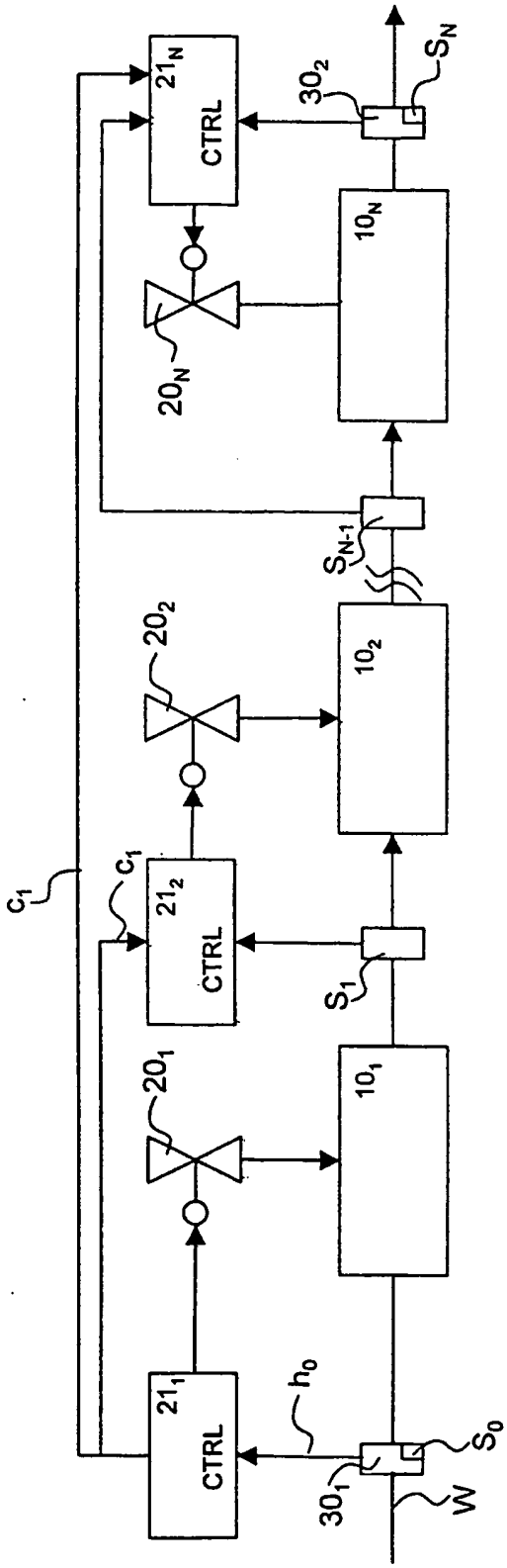
FIG. 3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30_1
W

FIG. 4

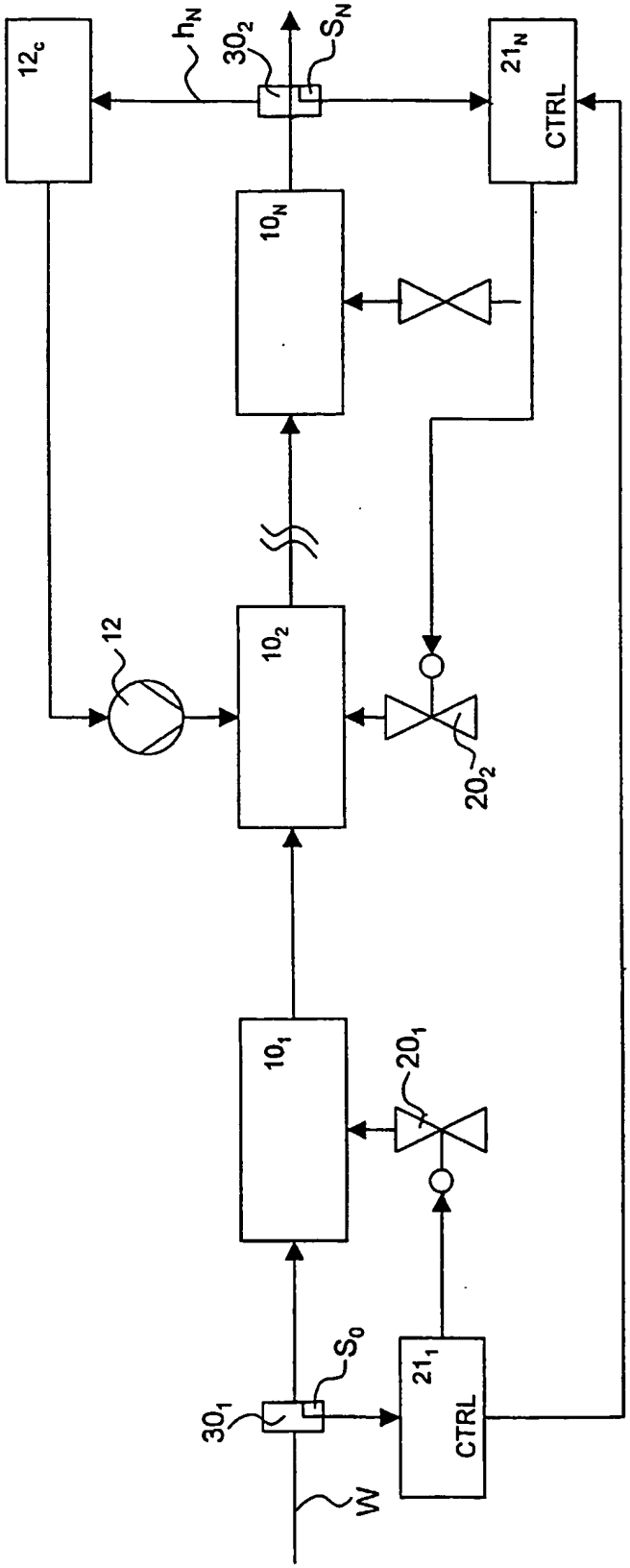

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 02/00612

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: D21F 5/18
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI DATA, EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 9936615 A1 (ABB FLÄKT AB), 22 July 1999 (22.07.99), page 2, line 11 - line 30; page 4, line 23 - line 36	1,2,13
A		3-12,14-17
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Y	SE 514397 C2 (ABB FLÄKT AB), 19 February 2001 (19.02.01), abstract	1,2,13
A		3-12,14-17
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P,X	WO 0250370 A1 (METSO PAPER, INC.), 27 June 2002 (27.06.02)	1-17
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 October 2002	23-10-2002
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Susanna Lindfors/ELY Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 02/00612

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E,X	WO 02063098 A1 (ABB FLÄKT AKTIEBOLAG), 15 August 2002 (15.08.02) -- --------	1-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/09/02

International application No.
PCT/FI 02/00612

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